Jet Propulsion Laboratory
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Spatially informed Aggregation of Orbiting Carbon Observatory measured XCO2 for Global Flux Inversion

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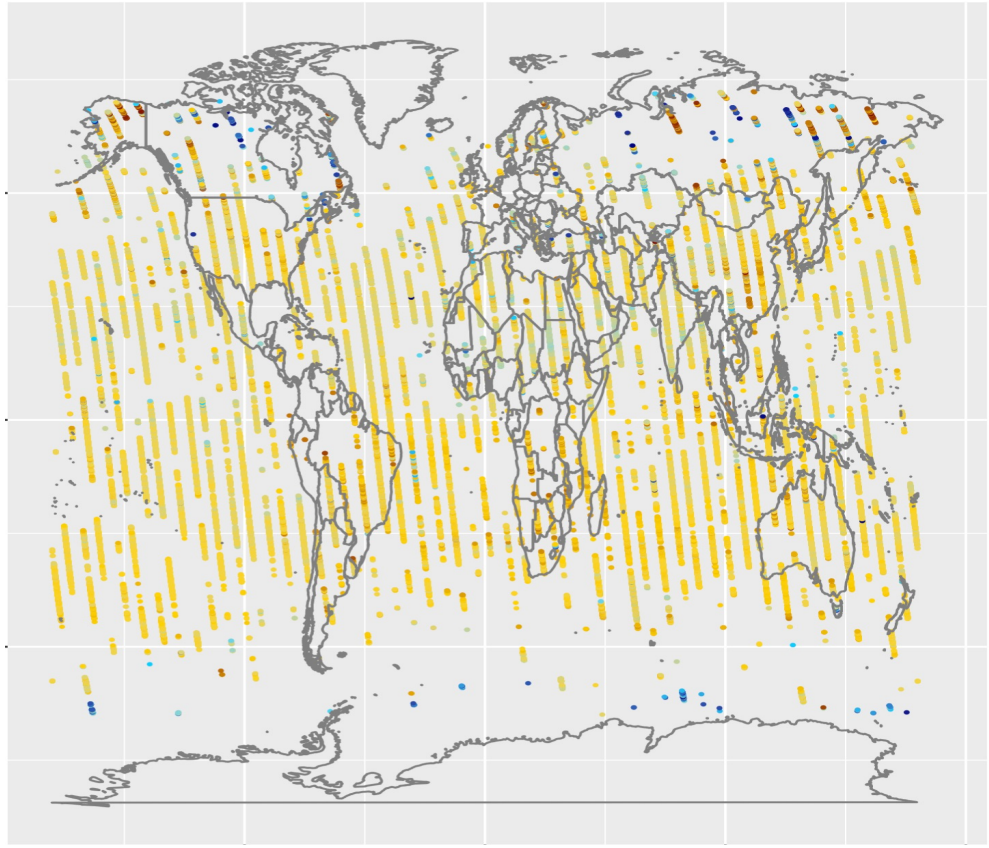
Orbiting Carbon Observatory-2

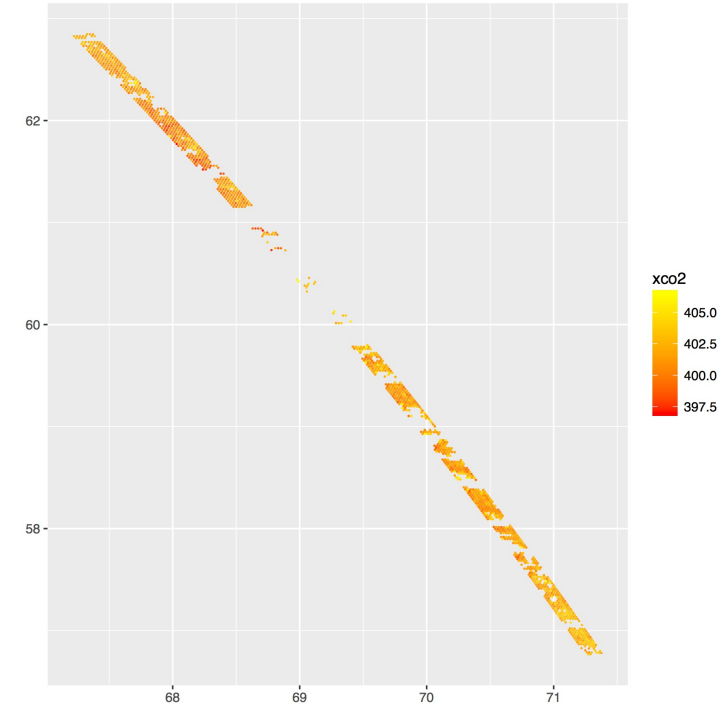
- Orbiting Carbon Observatory-2 (OCO-2) infers column averaged CO_2 (XCO_2) by measuring spectral radiance
- OCO-2's global measurements used in CO_2 flux inversion modelling

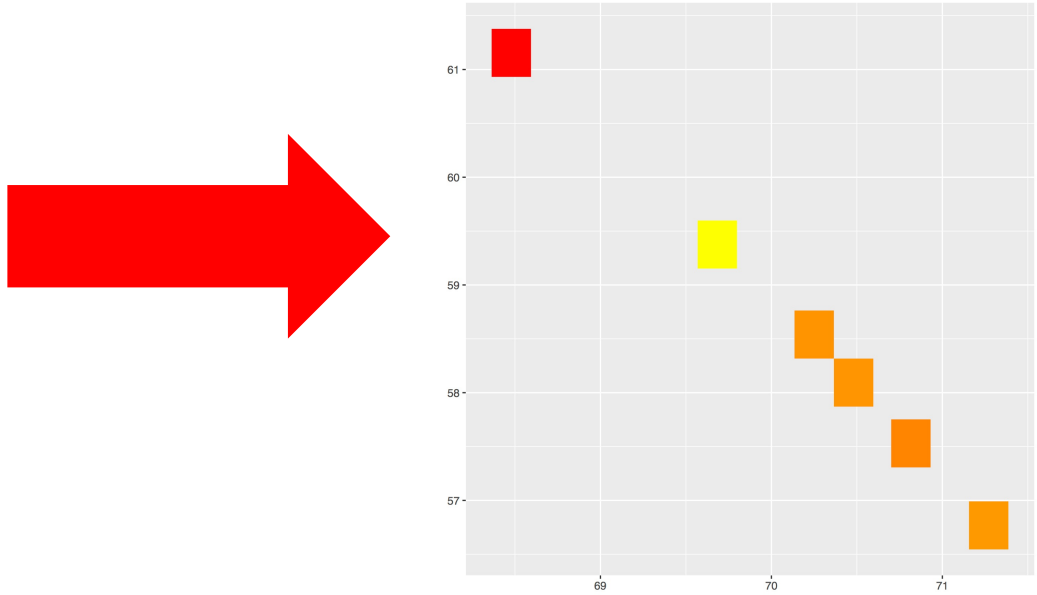
OCO-2 soundings week of 2015-10-11



Objective and Approach

- Aggregating level-2 OCO2 Data into 1°x1° blocks for flux inversion
- Localized Ordinary Block Kriging by orbit
- 4 Step process:
  - Estimate and remove latitude-dependent trend
  - Define spatial field
  - Estimate local covariance
  - Block Krige

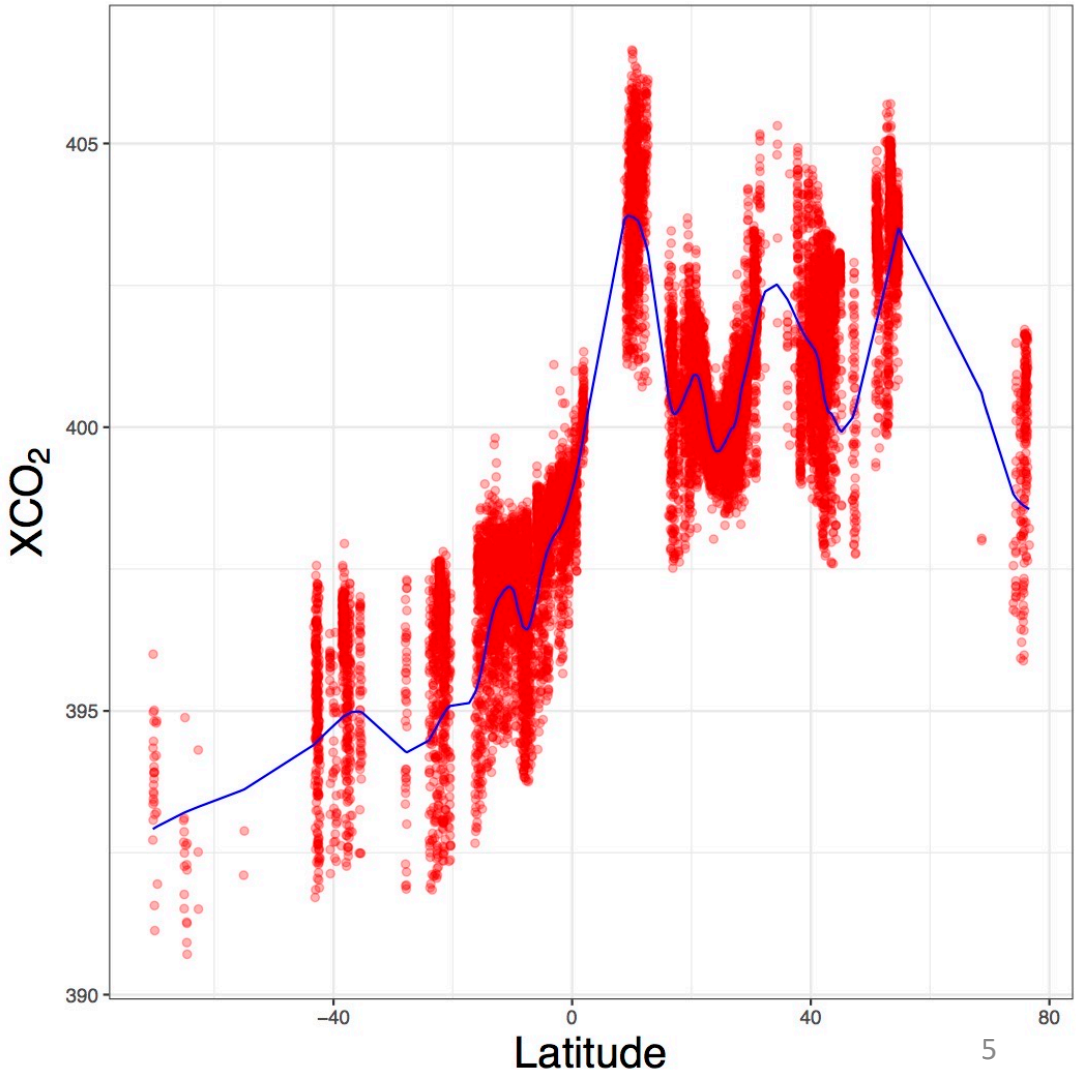




Detrending

- De-trend XCO_2 with respect to latitude using LOESS
- Outlier removal
- Covariance estimation and Kriging performed on detrended XCO_2

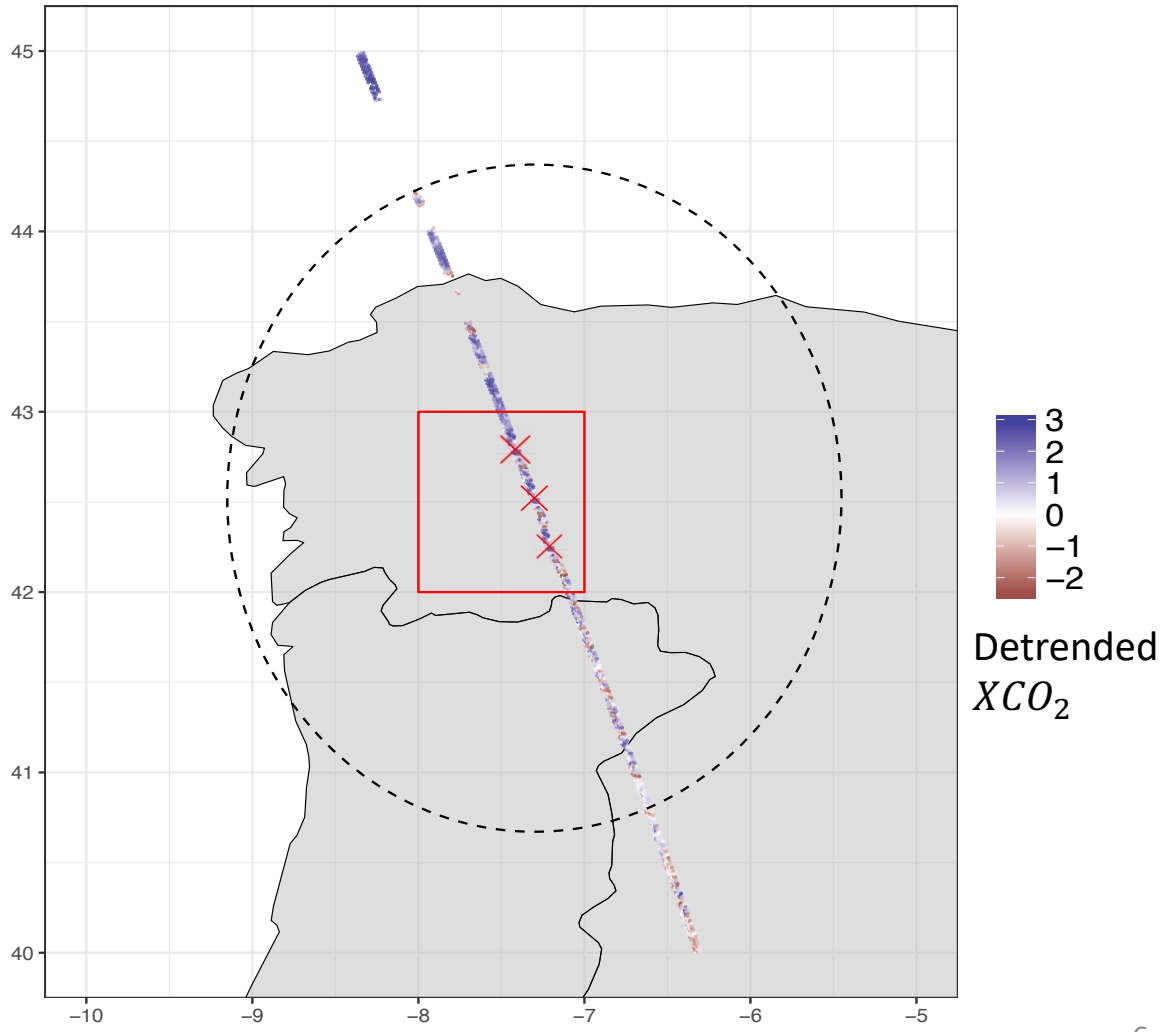
XCO_2 for all sample orbit footprints and latitude-dependent trend



Definition of Spatial Field

- Discretize orbit into degree boxes
- Define spatial field for each box with fixed radius
- Estimate spatial covariance of detrended XCO_2 within spatial field
- Block Krige over degree box

Spatial field for sample degree box



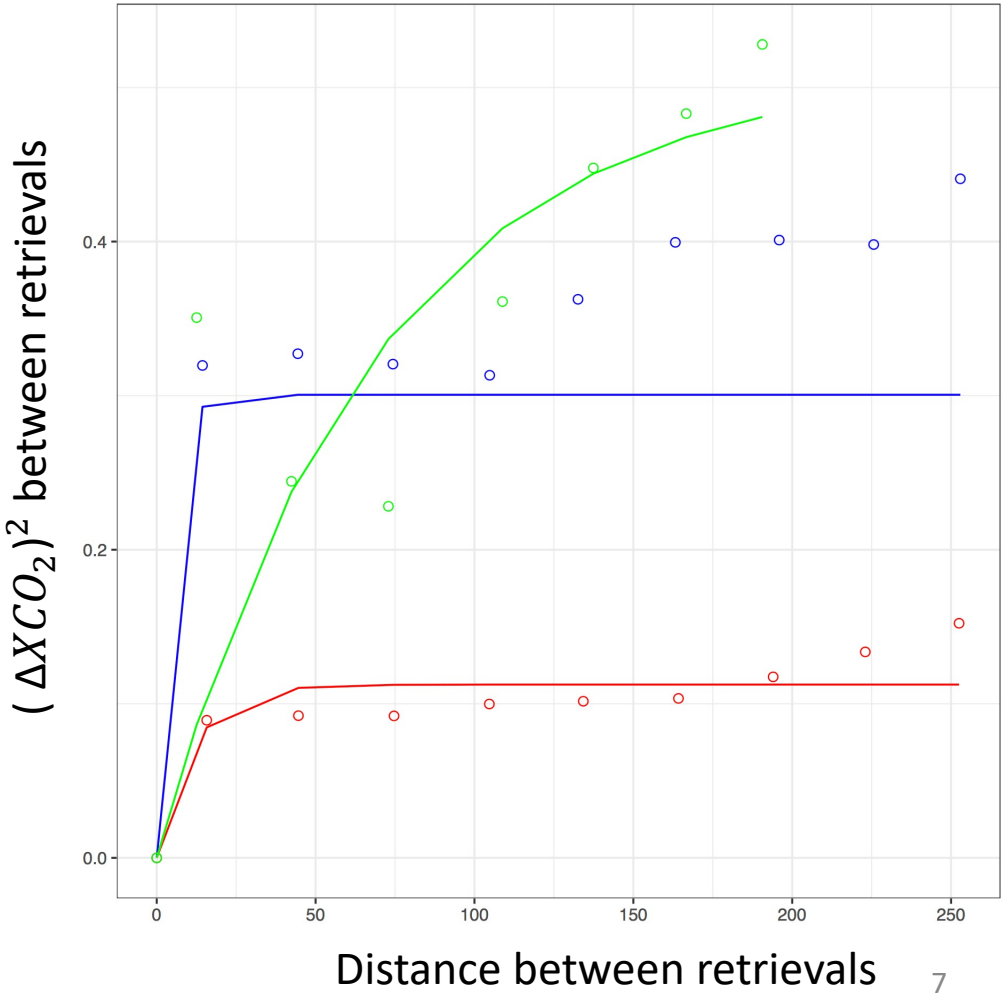
Empirical Covariance Estimation and Block Kriging

- Estimate covariance from empirical variogram of spatial field
- Assume variogram (γ) has exponential form:
  - Bin squared difference in XCO_2 value against distance for each retrieval
  - Fit exponential regression
- Covariance:

$$C(h) = C(0) - \gamma(h)$$

where h is the distance between two points

Fitted Empirical Variogram for different spatial fields



Empirical Covariance Estimation and Block Kriging (cont'd)

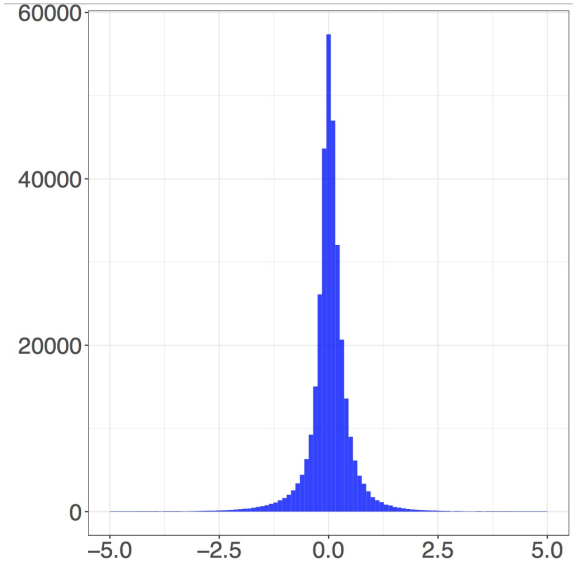
- Nugget Effect:
  - No nugget effect estimated
  - Individual retrieval uncertainties added separately to spatial covariance
- Estimate XCO_2 at 5 points across orbit
- Average mean estimate and uncertainty across 5 points

For all points s_i in a defined spatial field spatial covariance function C and matrix Σ, and kriging estimation points s_k

- $a_i = C(s_k, s_i)\Sigma^{-1}$
- $Z(s_k) = \frac{1}{N}\sum^{N} a_i \, x_i'$
- $\boldsymbol{x^* = LOESS(\overline{s_k}) + \frac{1}{5}\sum_{k=1}^{5} Z(s_k)}$
- $\widetilde{C}_i = \frac{1}{5}\sum_{k=1}^{5} C(s_k, s_i)$
- $\tilde{C} = the\ vector\ of\ \widetilde{C}_i\ for\ all\ s_i$
- $\sigma_K = \frac{1}{25}\sum_{k=1}^{5}\sum_{k\prime=1}^{5} C(s_k, s_{k\prime})$
- $\boldsymbol{\sigma^* = \sigma_K - \widetilde{C}^T \Sigma^{-1} \widetilde{C}}$

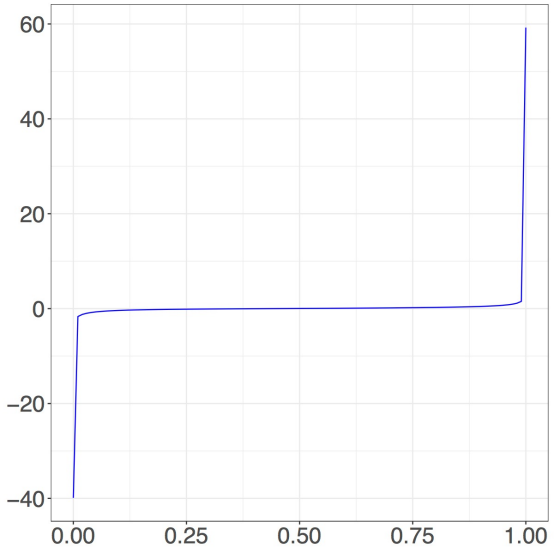
Comparison with 10 Second Average

- Global 2016 values compared
- Matched by nearest integer coordinate
- 90% of XCO2 Difference within +/- 0.6ppm
- 99% of XCO2 Difference within +/- 2ppm
- Mean difference: 0.0272 ppm
- Variance difference: 0.151 ppm

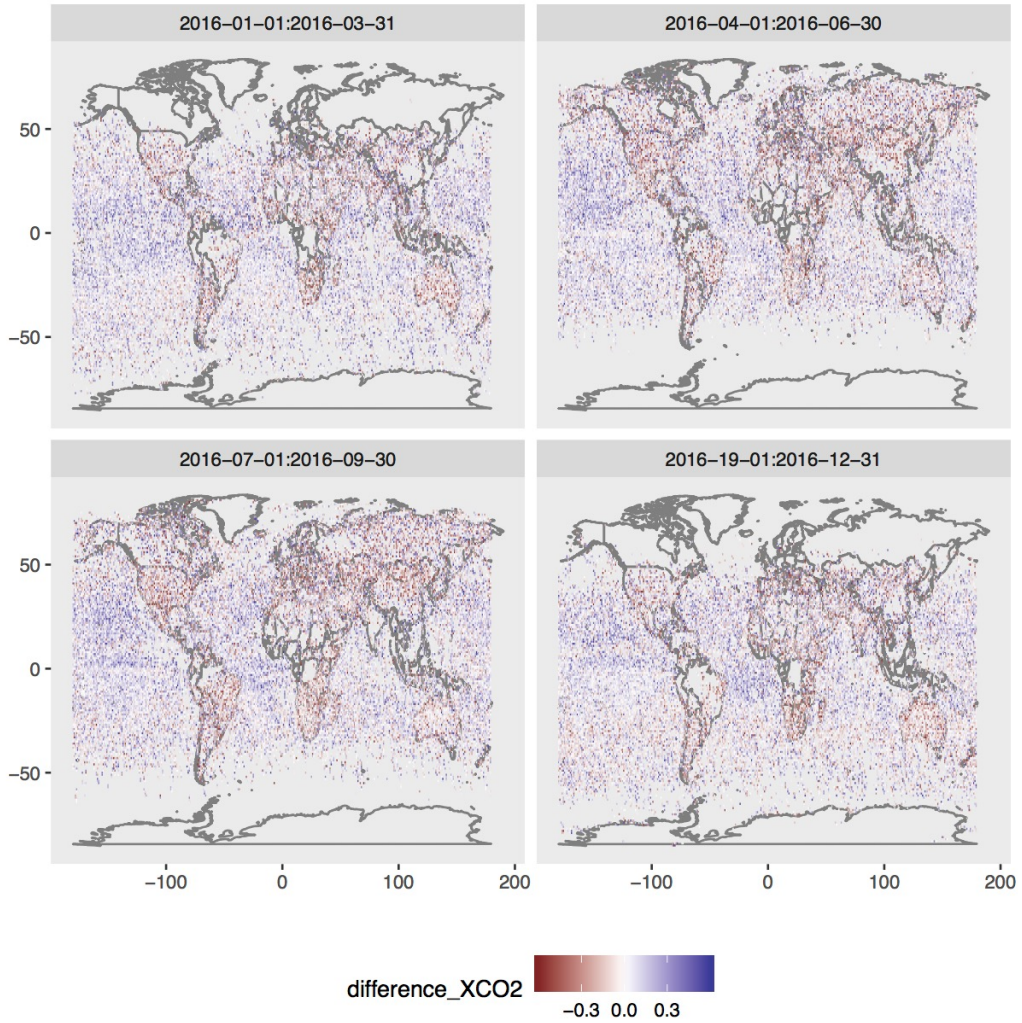


Spatial average – 10 second average

Spatial average – 10 second average CDF



Comparison with 10 Second Average



- Land/Ocean bias
- Mean land difference: -0.0564 ppm
- Mean ocean difference: 0.0475 ppm

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